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RESEARCH ARTICLE

Nesting habitat and density, nest characteristics, home ranges and group sizes of the Rufous-fronted Thornbird (*Phacellodomus rufifrons*) in Central Brazil

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Abstract

Rufous-fronted Thornbird (*Phacellodomus rufifrons*) reproduction has been studied under a few environmental conditions but might show some variations among regions throughout its wide geographic distribution. We describe here nesting habitat and density, nest characteristics, home ranges and group sizes of Rufous-fronted Thornbird in a Cerrado reserve in central Brazil. We found 131 nests in 2003, 2004, and 2011, and studied four groups inside a 100-ha grid. Nests were found only in *cerrado típico* and *cerrado ralo* but changed in abundance and density over the years, with a higher density in 2004 (0.37 nest/ha) than in 2011 (0.23 nest/ha). Nests were built 3.2 ± 1.0 m above the ground at 6.3 ± 0.2 m high trees of 31 species, but mostly of *Qualea* spp. Nests were 0.66 ± 0.27 m high and 0.44 ± 0.11 m wide. Home ranges had an average of 3.1 ± 0.3 ha, used by family groups of 4.6 ± 0.5 individuals. This study consolidates the findings of previous ones, but also highlights differences in habitat use, nest size, and nesting tree among regions or study sites, and changes in density among years, stressing the importance of studying the reproductive biology of the same bird species under different environmental conditions since different conditions might affect reproductive traits, such as reproductive investment and timing.

Keywords

Breeding, Cerrado, ovenbirds, reproductive biology, savanna

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PENSOFT

Introduction

The Rufous-fronted Thornbird *Phacellodomus rufifrons* (Wied-Neuwied, 1821), Furnariidae, is a polytypic Neotropical bird, with six subspecies occurring in four separate regions of South America (del Hoyo et al. 2020). It occurs on a variety of habitats, from dry areas to humid forests, but seems to require the presence of at least some trees to build the large thorny nests (Sick 1997; Costa et al. 2014, 2019; del Hoyo et al. 2020). In the Cerrado it has strong preference for *cerrado sensu stricto* and was not recorded in more open habitats in the Distrito Federal (Tubelis and Cavalcanti 2001), whereas in Minas Gerais it defended territories mostly in open fields and close to forest borders (Rodrigues and Rocha 2003). It has been proposed that the species relies on nearby water resources to maintain viable populations (Rodrigues and Rocha 2003). Also, nest size was much larger in the drier llanos than in the coastal mountains of Venezuela (Thomas 1983). Thus, habitat use may vary among regions throughout its geographic distribution, and nest size may vary among nesting habitats.

The reproductive biology of *Phacellodomus rufifrons* was studied in some detail (review in del Hoyo et al. 2020), both for *P. r. inornatus* (Skutch 1969a, b; Thomas 1983; Lindell 1996), as for *P. r. rufifrons* (Carrara and Rodrigues 2001; Rodrigues and Rocha 2003; Rodrigues and Carrara 2004; Bocchiglieri 2005; Ribeiro et al. 2007). The race most common in Brazil, *P. r. rufifrons*, lives in groups ranging from 2 to 10 individuals, whose territory is defended throughout the year (Carrara and Rodrigues 2001). It has a cooperative breeding system where other members of the group beyond the breeding pair assist in defending the 2–4 ha territory and feeding offspring (Rodrigues and Carrara 2004). The nest is used during the breeding season but also throughout the year as a dormitory (Carrara and Rodrigues 2001) and is built on forest borders and open fields (Rodrigues and Rocha 2003), and on several species of trees in *cerrado sensu stricto* (Bocchiglieri 2005). Despite these studies from both races, several aspects of the species' reproductive biology are still poorly described or restricted to a few localities.

Studies of density and distribution of bird nests are also important for medical reasons since birds' nests are used by a wide diversity of insects, including some disease vectors. The importance of birds' nests to the study of potential disease vectors was recognized long ago (Lent 1935), and solely in the Neotropical region insects from 34 orders were found in 172 taxa of birds (review in Di Iorio and Turienzo 2009). The nest of *P. rufifrons* and other furnariid can become infested with species of triatominae bugs (Triatominae: Hemiptera), potential vectors of *Trypanosoma cruzi* which transmit Chagas disease (Barretto and Carvalheiro 1968; Gurgel-Gonçalves and Cuba-Cuba 2007, 2011; Marti et al. 2014). Also, the use of *P. rufifrons* nests for breeding by several other species of birds (Skutch 1969b; Lindell 1996), suggest they might share parasites associated to nests. Thus, studies about the nest-

ing biology of bird species that build enclosed nests, like *P. rufifrons*, can help clarify aspects of the occurrence and distribution of potential disease vectors.

Considering the potential variation in breeding aspects among regions, and the limitation of reproductive studies of *P. r. rufifrons* mostly to one population in Minas Gerais (references above), and the potential of its nests as vector reservoirs in natural areas, we studied the reproductive biology of *P. rufifrons*, describing nesting habitat and density, nest characteristics and home ranges and group sizes in Central Brazil. Our study provides information on reproductive variables from a study site without forests and far away from water resources (in contrast to the Minas Gerais population), contributing to better understand the biology of this species in a landscape with different characteristics.

Material and methods

We collected data in a 100-ha grid at Águas Emendadas Ecological Station (ESECAE; 15°29'–15°36'S, 47°31'–47°41'W), a 10,547-ha protected area in the Distrito Federal, Brazil, within the Cerrado biome, a Neotropical savanna (location map in Duca and Marini 2014). The 1 × 1 km grid, was divided into four hundred 50 × 50 m squares on a flat topography at an altitude of ~1,040 m. The grid is covered with a mosaic of different vegetation physiognomies (Suppl. material 1: Table S1), in the following order, from more open to more closed: *campo limpo* (grassland), *campo sujo* (open shrub savanna), *parque cerrado* (savanna vegetation with distinctive woody vegetation on the discrete mounds), *cerrado ralo* (savanna vegetation with a sparse tree-shrub stratum with tortuous trunks, irregular branches, and a continuous grassy stratum), and *cerrado típico* (similar to *cerrado ralo* with higher tree density, height, and cover) (Silva Júnior and Felfili 1996; Borges and Marini 2010; Marini et al. 2012). The climate is highly seasonal, with a rainy season from October to April and dry winters from May to September. Mean annual rainfall ranges from 1,500 to 1,750 mm, and mean temperature ranges from 20 to 26 °C (da Silva et al. 2008).

We searched for nests in all months from July to September 2003, in January 2004 and from August to December 2011. The temporal gap of eight years occurred to allow for independent estimates, and the number of months surveyed in 2011 was possible due to better logistics. We searched ~75 ha in 2003/2004 and 100 ha in 2011 and confirmed nest activity by direct observations. Moreover, from August to December 2011, nest status (active or inactive) was determined by checking inside the nests every 3 to 4 days to register the presence of eggs and nestlings. We measured nests (height above the ground, length and diameter) with a measuring tape and nesting tree height with a marked 5-m long bamboo. All the standardized measurements were made by the same team of trained and experienced researchers.

We captured birds with mist nets during a long-term bird monitoring program and marked them with a metallic band provided by Centro Nacional de

Pesquisa para Conservação de Aves Silvestres (CEMAVE / IBAMA) and with a unique combination of three plastic color bands. Home ranges of each group were estimated from July 2003 to January 2004, by visual mapping following banded individuals and plotting all occurrence points on a map grid. Home range was defined as the area used by individuals to live and reproduce (Maher and Lott 1995). Playback was performed to locate groups when it was difficult to locate them, usually on rainy days or on very hot and dry days. After each observation period the recorded points were connected by the largest convex polygon method (Odum and Kuenzler 1955). Stabilization of the home range was detected by analyzing visually the asymptote of the curve of cumulative area. We followed when possible the recommendations for reporting home range analyses provided by Laver and Kelly (2008).

We estimated the density of active nests (Dn) in the study area in 2004 and 2011 using the formula, Dn = Nn / V, where Nn is the number of active nests in the grid and V is the percentage of vegetation type where birds built nests inside the sampled area in the grid. After classifying the vegetation, V was estimated as 51.7% (percentage of *cerrado típico*) in 2004 and 81.3% (sum of the percentage of *cerrado típico* and *cerrado ralo*) in 2011. These values vary over the years because areas of different sizes were sampled in each year. We tested whether nests were associated or not with vegetation types using chi-square analysis and Fisher Exact test in program R. We set significance at $\alpha = 0.05$. When presented, means are followed by standard errors (SE).

Results

Nesting habitat and density

We found 131 *P. rufifrons* active and inactive nests, 44 in 2003, 51 in 2004 and 36 in 2011, only in *cerrado típico* and *cerrado ralo* (Figs 1, 2). The number of nests found in *cerrado ralo* was higher in 2011 (n = 11) than in 2004 (n = 4), and in *cerrado típico* was lower in 2011 (n = 26) than in 2004 (n = 48) (χ^2 with Yates correction = 7.96, d.f. = 1, $p < 0.05$). Nest density was higher in 2004 (Dn = 0.37 nest/ha) than in 2011 (Dn = 0.23 nest/ha).

Nest characteristics

We measured 72 nests and identified 31 species of trees that were used as substrates to build nests, of which the genus *Qualea* was the most used (Fig. 3; Suppl. material 1: Table S1), with four different species and some trees with two nests. They built nests mostly with sticks and cotton-like materials, but two nests also used pieces of paper and plastic, and feathers. Nests were on average 0.7 m long and 0.4 m wide, located 3.2 m above the ground on trees 6.3 m high (Table 1).

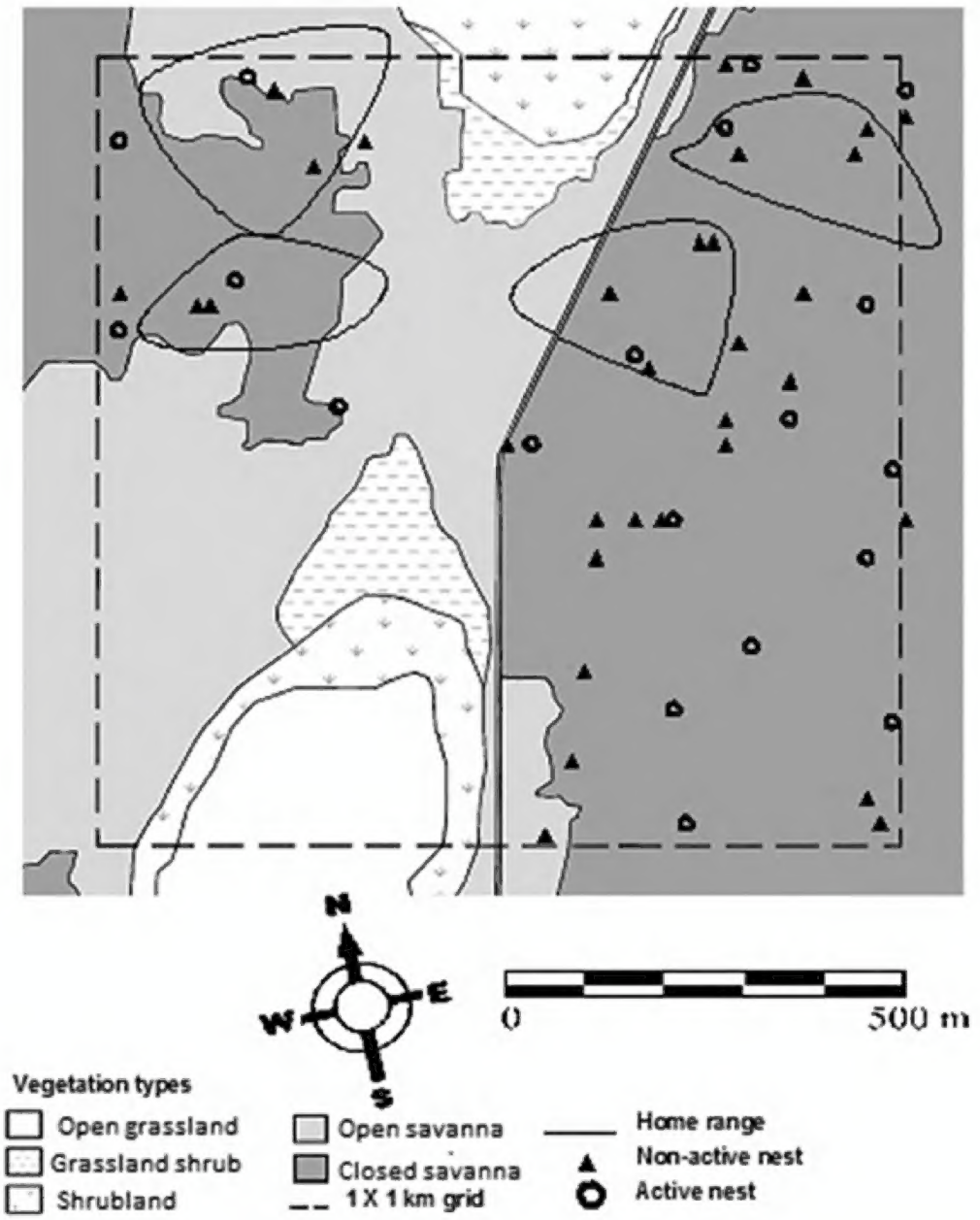

Figure 1. Location of the home ranges and active (○) and inactive (▲) nests of *Phacellodomus rufifrons* during the breeding season of 2004 in the Águas Emendadas Ecological Station, Distrito Federal, Brazil.

Table 1. Measurements of *Phacellodomus rufifrons* nests built in the Águas Emendadas Ecological Station, Distrito Federal, Brazil, and studied by Carrara and Rodrigues (2001) and Rodrigues and Rocha (2003) in Minas Gerais, Brazil.

Nest characteristics	N	Mean ± SE (range)	Mean	
			Rodrigues and Rocha (2003)	Carrara and Rodrigues (2001)
Height above the ground (m)	72	3.19 ± 1.00 (1.45–6.45)	3,64	3,72
Length (m)	72	0.66 ± 0.27 (0.25–1.20)	0,58	0,6
Diameter (m)	72	0.44 ± 0.11 (0.25–0.70)	–	–
Height of nesting tree (m)	44	6.3 ± 0.2 (3.3–10.0)	–	7,5

Home ranges and group sizes

The four groups with 2–6 birds (Nm = 4.6 ± 0.5), had home range sizes of 2.5–4.0 ha (3.1 ± 0.3 ha), always in *cerrado típico* and *cerrado ralo*. Most individuals answered to playback by flying and vocalizing, but we did not record agonistic interactions between individuals of different groups.

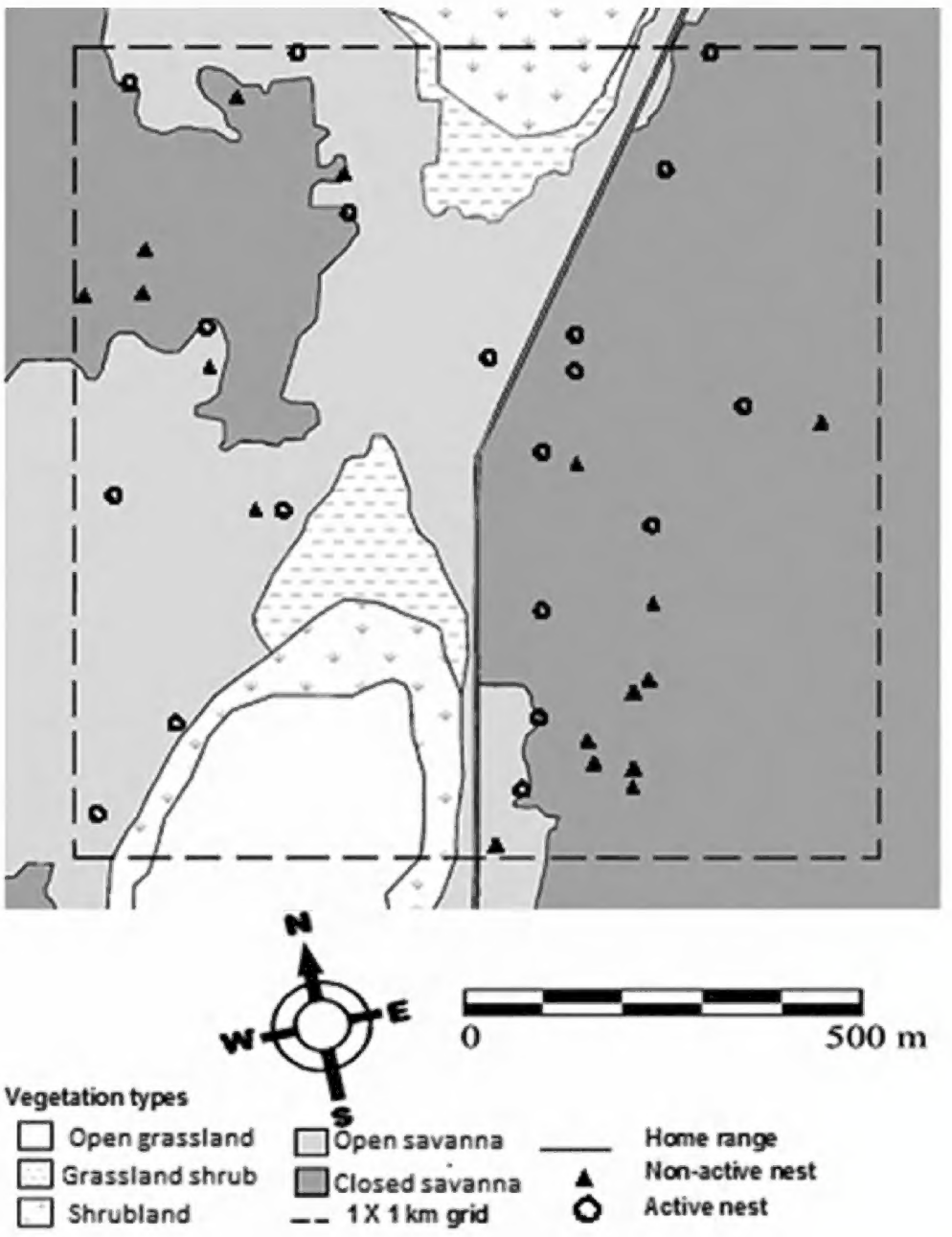

Figure 2. Location of active (○) and inactive (▲) nests of *Phacellodomus rufifrons* during the breeding season of 2011 in the Águas Emendadas Ecological Station, Distrito Federal, Brazil.

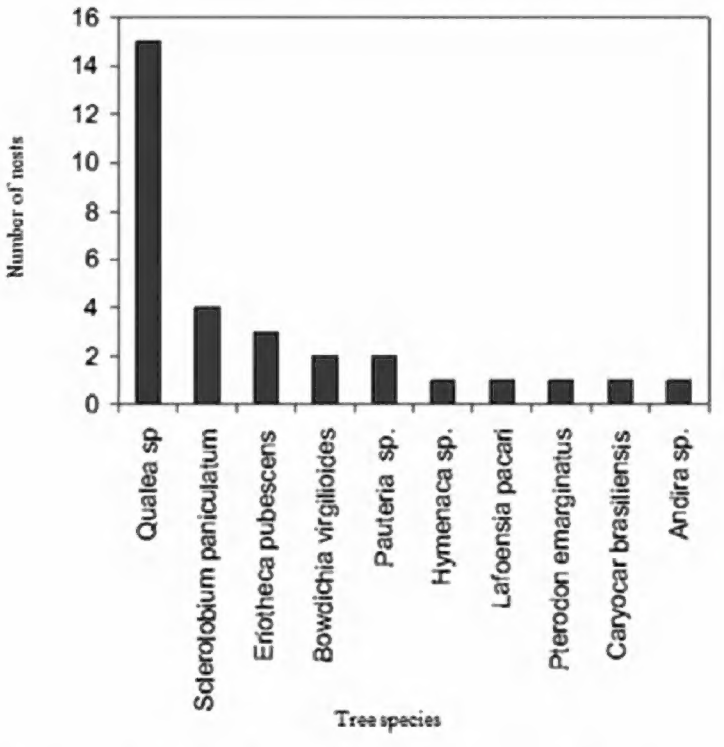

Figure 3. Species of trees used by *Phacellodomus rufifrons* to build nests during the breeding seasons of 2003 to 2004 in the Águas Emendadas Ecological Station, Distrito Federal, Brazil.

Discussion

Our study of four groups and 131 nests of *P. rufifrons* in a 100-ha grid of Cerrado allowed a refined analysis and helps reaffirm previously reported aspects of its reproductive biology. Nests were found only at in *cerrado típico* and *cerrado ralo* and never at the more open vegetation types (Figs 1, 2). However, we observed a change in nests' spatial distribution, with more nests found at *cerrado típico* in 2004 and more nests at *cerrado ralo* in 2011. Besides the expansion of the nest search area, encompassing more *cerrado ralo* in 2011, there was a noticeable decrease in nests at the eastern portion of the grid, where the *cerrado típico* is more common. We hypothesize that this change in distribution of nests inside the grid over a period of seven years was due to a possible increase in vegetation density related to the absence of fire between 2002 and 2011. Fire exclusion leads to an increase in woody elements in Cerrado physiognomies and is particularly important in more open areas (Moreira 2000; Libano and Felfili 2006). This apparent change in vegetation density might also explain in part the lowest nest density in 2011, with the *cerrado típico* areas becoming too closed and less attractive, and the *cerrado ralo* having taller trees more attractive to breeding pairs.

Other explanations for these changes include an increase in home range sizes because of possible lower productivity at *cerrado ralo* than at *cerrado típico*, and a decrease in population size in 2011 compared to 2004. However, this last explanation is unlikely since capture rates at mist-nests at the study grid were similar during this period (M. Â. Marini, unpublished data). Lastly, since our study grid is far away (> 2,000 m) from water bodies (i.e. rivers, lakes, etc.), the proposal by Rodrigues and Rocha (2003) that *P. rufifrons* depends on some water resource to establish viable populations was not supported. The species seems to have some flexibility in habitat use, nesting in more humid habitats, such as the coastal areas in Venezuela (Thomas 1983), or veredas (Gurgel-Gonçalves and Cuba-Cuba 2007), and much drier habitats, such as the Caatinga (Gurgel-Gonçalves and Cuba 2011). It seems that nest site choice, hanging high on trees, is related to protection against fire and predators (Carrara and Rodrigues 2001), and the isolation degree of nesting trees seems to be an important factor in determining nest site (Carrara and Rodrigues 2001; Rodrigues and Rocha 2003).

Nest measurements were similar to those found in other studies (Carrara and Rodrigues 2001; Rodrigues and Rocha 2003). They were also similar in size to the ones in the drier areas but were larger than the ones in more humid areas from Venezuela (Thomas 1983). This change in nest size among regions might be related to differences in climatic conditions or availability of nesting material. Nests were similar in shape and were built with similar materials as previously reported, but also had anthropogenic materials, as found by Skutch (1969a) and Thomas (1983) in Venezuela. The Pale-breasted Spinetail (*Synallaxis albescens*), who also builds enclosed nests with sticks, also used anthropogenic materials at our study grid (Marini et al. 2012). The presence of plastic, paper and other anthropogenic materials in birds' nests can decrease their breeding success (Borges and Marini 2010)

because these artificial materials make nests more conspicuous to visually oriented predators. As expected, we found one or more nests on the same tree which were probably built by the same breeding pair. This is a common behavior for this species, with up to three nests recorded in Minas Gerais (Rodrigues and Rocha 2003) and up to five nests recorded in Venezuela (Thomas 1983). As suggested for another furnariid (Pink-legged Graveteiro – *Acrobatornis fonsecai*), these multiple nests in the same tree may confuse predators or parasites and may serve as resource stores (Whitney et al. 1996).

Phacellodomus rufifrons seems to use a wide variety of plants to build its nests, but that have specific requirements. Nearly half of the nests we found were built on *Qualea* trees (Vochysiaceae), among the commonest woody plants throughout central Brazil (Felfili et al. 2000), and with four or five species found at ESECAE (Felfili et al. 2007). However, at another reserve also at the Distrito Federal, *Pterodon pubescens* (Leguminosae) was the most used tree species (Bocchiglieri 2005). Usually the nesting trees are large in size with a wide crown and occur in low density, frequency and dominance in open areas of central Brazil (Bocchiglieri 2005). This same result was found by Carrara and Rodrigues (2001) at Minas Gerais, who argued that this pattern reflects the abundance of those trees in the area. Thus, it seems that *P. rufifrons* nest-site choice is more related to plant architecture and plants spatial distribution than to the plant species (Bocchiglieri 2005).

The home ranges we estimated (2.5–4 ha) are similar in size to the territory sizes (2–4 ha) reported by Rodrigues and Carrara (2004), suggesting that there is little variation in their sizes among Cerrado phytophysiognomies probably due to similar habitat qualities. Group sizes ranged from 2–6 birds in our study site but reached up to eight birds in Venezuela (Skutch 1969a) and up to 10 birds in Minas Gerais (Carrara and Rodrigues 2001). These differences in group size might be related to nest predation rates, which were very low in Minas Gerais (Carrara and Rodrigues 2001), or to differences in habitat quality, although bird densities seemed similar between Minas Gerais and our study site. We did not observe agonistic interactions between individuals of different groups, but Skutch (1969a) observed in Venezuela birds defending territories by singing and chasing each other.

In conclusion, the large number of *P. rufifrons* nests monitored in this study consolidates the findings of previous studies (nest height above the ground, nest substrates and family group size), but also highlighted the differences in habitat use, nest size, and nesting tree among regions or study sites, and changes in density among years. This study stresses the importance of studying the reproductive biology of the same species of bird in diverse environmental conditions, since different conditions might affect reproductive traits, such as egg and clutch size, and breeding period and length. Also, a better knowledge of breeding and population parameters of *P. rufifrons* in different biomes, habitats, climates and latitudes can be useful to understand how this species responds to varied environmental conditions.

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Supplementary material 1

Table S1

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Data type: tree characteristics

Explanation note: Height above the ground (m), length (m), diameter (m), tree height (m) and identification of the support plant of the 44 nests of *Phacellodomus rufifrons* found at the Águas Emendadas Ecological station, in 2003.

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